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Award Number: W81XWH-06-1-0112

TITLE: E- Design Environment for Robotic Medic Assistant

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REPORT DATE: December 2006

TYPE OF REPORT: Final

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE	**2. REPORT TYPE**	**3. DATES COVERED**
01-12-2006	Final	15 Nov 2005 – 14 Nov 2006

4. TITLE AND SUBTITLE

E- Design Environment for Robotic Medic Assistant

5a. CONTRACT NUMBER

5b. GRANT NUMBER
W81XWH-06-1-0112

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

University of Pittsburgh
Pittsburgh, PA 15260

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Included in report

15. SUBJECT TERMS
Robotics, collaborative design, medical material design & development, mobile hospital, loading plan, reconfiguration, stimulation, acquisition

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			USAMRMC
U	U	U	UU	9	**19b. TELEPHONE NUMBER** *(include area code)*

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

Abstract

This status report summarizes the research work of e-design environment for Robot Medic Assistant (RMA) conducted at the National Science Foundation Industry/University Cooperative Research Center for e-Design from Nov. 2005 to Nov. 2006. The major tasks performed include identification of stakeholders and technical challenges in collaborative RMA design, research extension and collaboration with Army Research Laboratory, identification and implementation of collaborative technologies for e-design environment.

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Summary of Activities Performed in 2006

1. Identification of Technical Challenges in Collaborative Design of Robotic Medic Assistants

A meeting with RMA design stakeholders is held on January 5, 2006 to discuss the basic functional needs of future collaborative design environment for RMAs. These include being able to communicate efficiently and effectively on design requirements and specifications, especially between end users and system designers; mechanisms of soft and hard constraint capturing, categorization, and management; concept and model repository for design and knowledge reuse; tools for lifecycle prototyping and simulation; and knowledge and document management systems. These needs are also common for other type of products in general.

2. Research on Soft Constraint Formulation and Imposition in Human-Centric Robot Design

Dr. Yan Wang at the University of Central Florida (UCF) initiated the collaboration with the U.S. Army Research Laboratory Human Research and Engineering Directorate (ARL-HRED) in the research program of "Team Performance and Optimization in Human-Agent Collaboration". The purpose of the program is to understand human-robot and human-agent interactions, assess their determinants, and to develop and evaluate technologies to improve the battlefield performance for Future Combat Systems (FCS) and the Future Force Warrior (FFW). This new research program has also joint efforts with other robotics research institutes, including UCF Institute of Simulation and Training (UCF-IST), Institute for Human and Machine Cognition (IHMC), University of South Florida (USF), and Florida State University (FSU/FAMU).

This research extension is to investigate a new modal interval based soft constraint representation in granular computing, an emerging conceptual and computing paradigm of information processing. It is an intention of describing a way of thinking that relies on human ability to perceive the real world under various levels of granularity. A new algebraic soft constraint system for human-robot collaborative problem solving is being studied. Semantics of constraints and intent thus can be integrated into numerical calculation. As the width of interval values in soft constraints is narrowed down during problem solving process, the granularity of information is increased, and softness is reduced. The interpretability of soft constraints is studied with the exploration of human-agent problem solving taxonomy. Criteria of modality selection and categorization of intent is being formalized. Dependency relationship among requirements and specifications is being studied.

3. Identification of Enabling Collaborative Technologies

Collaborative design infrastructure should enable human-human, system-system, and human-system collaboration. The basic capabilities that are identified include:

(1) Web portal environment for human-human collaboration
   a. document and knowledge repository
   b. fine-grained document and design sharing
   c. multimodal teleconference and archiving
   d. online discussion and archiving
   e. screen capturing, animation, and demonstration

(2) Communication protocols for system-system collaboration
   a. process modeling and management
   b. asynchronous and synchronous remote procedure call
   c. data markup and linkage
   d. report generation and data visualization
   e. heterogeneous data mapping and wrapping
   f. trusted computing for intellectual property protection

(3) Human-centric computing paradigm for human-system collaboration
   a. Multimodal human-machine interface
   b. Computing with words, computing with perception, soft computing
   c. Natural language processing
   d. Semantics / intent representation and mining

4. Implementation and Testing of Collaborative Tools

(1) Video Conferencing

A next-generation video conferencing tool, ConferenceXP, has been tested. It is a new broadband video conferencing system being researched and developed at Microsoft Research. It supports multiple meeting venues, multiple site unicast and multicast, and video archiving. Collaborators can have real-time communication and presentation during sessions.

(2) Design Repository

A new middleware-based cross-platform design information and knowledge repository is being developed with a combination of WebSphere, DB2, Web portal. It is aimed to eventually provide a design archiving and searching capabilities for design engineers to store and retrieve design and concepts in different forms (text, image, 3D model, audio, and video).

(3) Security & Intellectual Property Protection

A model of fine-grained access control model is created to allow for document sharing among stakeholders with the consideration of intellectual property (IP) protection. A prototype of IP rights validation web service is being implemented.

Appendices

I. Minutes from Robot e-Design Meeting of RMA Stakeholders
II. List of related publications

APPENDIX I. Robot e-Design Meeting Minutes

Discussion of Process for Inclusion of Stakeholders in e-Design Process
January 5, 2006

Purpose of the Discussion Forum:
To ascertain how the *e*-Design platform will be adapted to the design of the robot medic assistant (RMA); how the collaboration, exchange of ideas, and imposition of constraints will take place on a large complex project such as RMA

Basic Questions Discussed:
What do stakeholders need in e-Design?
What tools are needed to make RMA development more efficient?

Requirements, Specifications, Constraint Management Needs:
- Ability to speak and understand the same language when translating military requirements into design specifications; constraint clarification
- Tools for consistent management of requirements/specifications when there is no interaction with the originators of the requirements (more than a book of requirements)
- Tools that manage virtual/draft requirements; requirements that are not yet official yet work can begin on them immediately
- Sources of requirements from other existing projects and platforms that may apply to the exist project
- Ability to classify and manage constraints appropriately into military, operational or other constraints categories
- Ability to prioritize constraints into preferences, soft constraints, or hard constraints in order to make better decisions on design alternatives (use of AHP and other methods)
- Advisor for when constraints should be applied; Forward chaining/backward chaining constraint check
- Ability to verify and show that all specifications have or have not been met for a particular design (ignored constraints must be acknowledged)
- Tools for developing and assessing human factors constraints, particularly in the context of soldiers who will be carrying various equipment
- Tools that test JAUS complicacy and determine if there is true interoperability among components

Concept Development Needs:
- Tools for concept validation
- Tools for collaboration in concept development
- Tools that enable cost-effective creation of concept videos and concept graphics
- Image libraries to aid the development of conceptual scenarios

Testing and Feedback Needs:
- Tools that allow for early prototyping and test so that early revisions can be made and applied the design

- Tools that allow for the quick location or development of candidate environments and location in which the robot will be tested
- The ability to infer if requirements are met (e.g., a soldier focusing too much on a controller infers a greater risk of being harmed)
- Advisor to help with decisions based on test results
- Immediate availability of test results

Information Sharing Needs:
- Intellectual property protection; share designs/info without risking intellectual property
- Sharing policies and protocols that are defensible in court
- Protocols that share only the information that is needed
- Tools for quick organized user feedback

Engineering Knowledge Needs:
- Solutions to small problems, availability/sharability of information so that "reinventing the wheel" can be avoided
- Advanced search or expertise exchange of knowledge (individual websites are not good enough for finding solutions)
- Tools that allow you to focus on your core competencies so that you do not have to try to find solutions to side issues; let experts focus on side issues
- Knowledge base of Lessons learned
- Military terminology and acronym dictionary
- What other military programs/contracts exist that are similar to the current one

Management Needs:
- Business processes tools for management, accounting contracting, HR/recruiting, marketing/research, communications, consulting/advising, process analysis, QFD, etc.
- Means to collaborate with non-fixed corporate cultures (i.e., a group of small startups have varying cultures unlike a mature well established supply chain)
- Electronic integrated product team process
- Automatic non-disclosure agreements
- Automatic updating of military plans
- Automatic/expedited human use approval
- Automatic updating of references
- Automatic report generation
- Tools to monitor markets for the product
- Means to conduct effective QFD meetings
- Tools that tell you what's going on

Miscellaneous Thoughts
- How to make the Center for e-Design known to other contractors, collaborators, industries
- The role of smaller robotics companies in the larger picture of e-Design
- How to bring together a group of entities to build a large system

APPENDIX II. Related Publications

- Wang, Y. and Nnaji, B.O., "Document-Driven Design for Distributed CAD Services in Service-Oriented Architecture," *ASME Transactions Journal of Computing and Information Science in Engineering*, Vol.6, No.2 (June 2006), pp.127-138

- Wang, Y., Ajoku, P.N., Brustoloni, J.C., and Nnaji, B.O., "Intellectual Property Protection in Collaborative Design through Lean Information Modeling and Sharing," *ASME Transactions Journal of Computing and Information Science in Engineering*, Vol.6, No.2 (June 2006), pp.149-159